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Advanced Pitch Angle Control Configuration of Wind Energy Conversion System with Different Control System Configuration

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ABSTRACT

This paper deals with the control strategy of wind turbine as the energy transformation takes place from kinetic energy to electrical power. Wind turbine bears different types of loads and this loads can cause vibration and fatigue in blades and cause degradation of blades of wind turbine and these loads can be reduced by better understanding of wind loads and characteristics of wind and design a fuzzy logic control system for the pitch angle. In this paper an advanced pitch angle control system has been designed based on fuzzy logic control system. As the wind speed is having nonlinear characteristics this fuzzy logic controller can compensate this nonlinear characteristics of the pitch angle to wind speed. A conventional PID controller has also been introduced in the model as used in conventional systems and the comparison of both the control system has been analyzed by the simulation results.

KEYWORDS: *Fuzzy logic controller (FLC), Pitch angle controller, THD (Total harmonic distortion), STATCOM (static synchronous compensator), Permanent magnet synchronous generator (PMSG), Insulated gate bipolar transistor (IGBT)*

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INTRODUCTION

In today's world the fossil fuel consumption increasing day by day and the reason behind use of fossil fuels is to generate more and more power in conventional manner. Due to excess use of fossil fuels bad impacts on environment increasing and affects all. Due to this reason renewable energy sources for generation of power is promoting by the government of many countries and so many schemes regarding this power generation system has been launched.

The world constraint of fossil fuels reserves and additionally the ever growing environmental pollutants have driven powerfully throughout ultimate many years the occasion of renewable strength sources (RES). The necessity of getting obtainable property power systems for substitution bit through bit trendy ones demands the improvement of systems of power provide based on smooth and renewable resources. At present, solar electric photovoltaic (PV) era is ahead redoubled significance as a RES application because of distinctive blessings like simplicity of allocation, high responsibility, absence of gasoline value, low preservation and absence of noise and wear thanks to the absence of moving factors or practical's. Moreover, the alternative energy characterizes a clean, pollutants-loose and inexhaustible power supply. Additionally to those elements are the declining value and expenses of solar PV modules, associate degree increasing efficiency of sun cells, producing generation enhancements and economies of scale [1].

For the installation of wind energy MNRE scheme (The Ministry of New & Renewable energy) has introduced to aware more and more people about this technology, government also gives incentives in order to promote wind energy. Wind is air in motion; this is actually derived from solar energy. About 2% of total solar flux that reaches the earth's surface is transformed into wind energy due to uneven heating of atmosphere. This kinetic energy of wind is used to gain the rotational motion of wind turbine which is coupled with an electrical generator to supply over a region acting as stand-alone or supplying power to a

grid. An actual WECS (Wind energy conversion system) be considered as follow [2]

As per the energy scenario we can see that power demand increasing every year and within next few years it will increase in a large manner and in several lakhs of Megawatts and to fulfil all this requirement power generation will also increase and due to the use of excess fossil fuels increase in the level of carbon monoxide and other toxic gases will also increase and affect the environment badly. So A clean energy and green energy schemes should be increased by increasing the power generation capacity by renewable sources like solar and wind energy.

As far as wind and solar energy generation system is concerned the installation cost is high and generating power is also quiet challenging as the main source is nonlinear that may be sunlight or wind energy. So many researches is going on this fields to make this renewable energy system highly efficient and the payback period in the form of energy saving will be lesser.

In this work a wind energy conversion system has been designed and the main area of research is to control the pitch angle of wind turbine in this regards many control system has been already designed to achieve the best output from the nonlinear wind energy. A fuzzy system has been designed with predefined inputs and rules according to the rules to achieve much better desired output.

PROPOSED MODEL

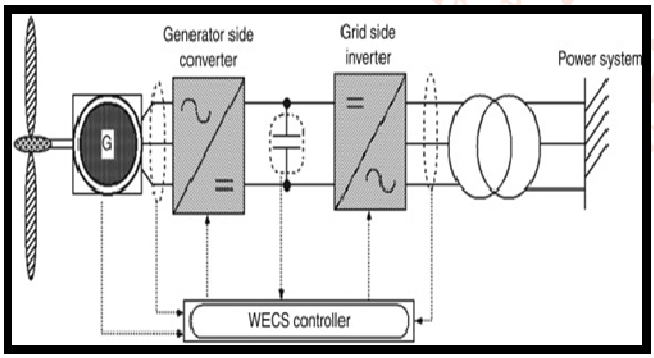

Figure 1 Block diagram of wind energy system connected with grid

Figure 1 shows the wind energy system connected with grid but as we know that wind flow are not in the same intensity throughout the day due to nonlinear behavior or some other disturbances and due to this reason wind energy is unreliable. The pitch angle control is necessary due to the above reason.

Implementation of conventional PID control system

The Simulink model of wind turbine pitch control system with conventional PID controller is shown in figure 2 and the control parameters shown in figure 3 [3]

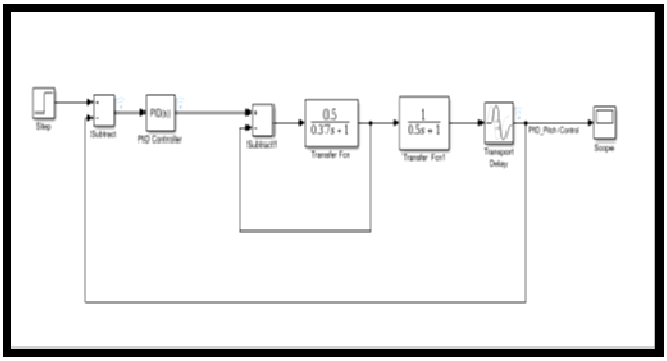

Figure 2 Simulink diagram of PID controller

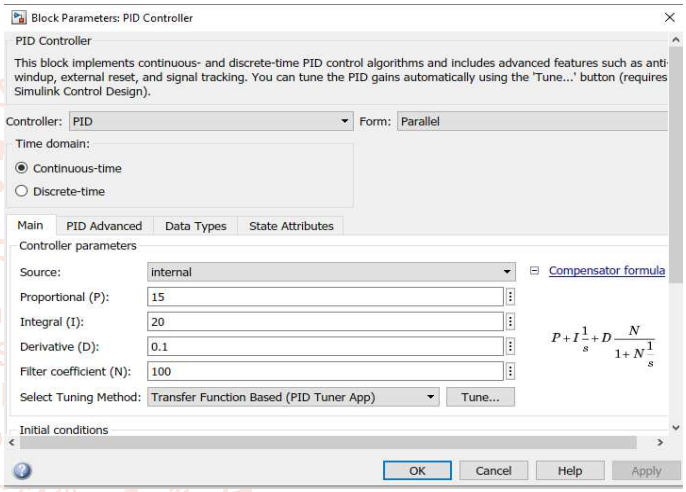

Figure 3 Parameters of PID

Fuzzy Control System

The best way to control he blade pitch angle is rule based fuzzy logic control system. Fuzzy logic system is a good practice for the system having parameters fluctuated from the expected value. Fuzzy logic control of pitch angle is considered as a modern technique to achieve near about the desired output.

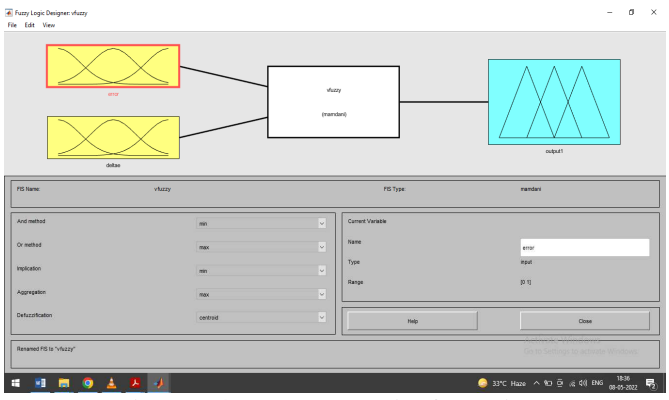

Figure 4 Membership functions

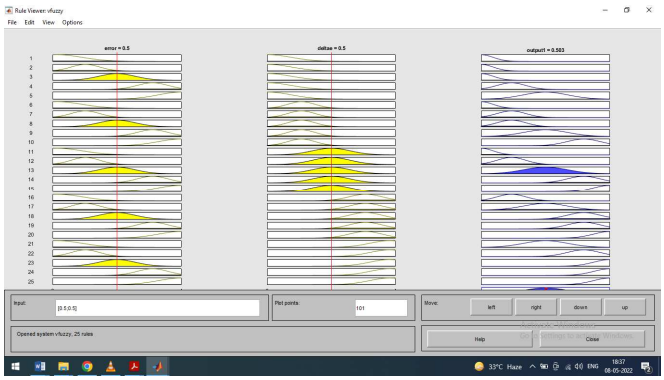

Figure 3 Rule view of fuzzy control system

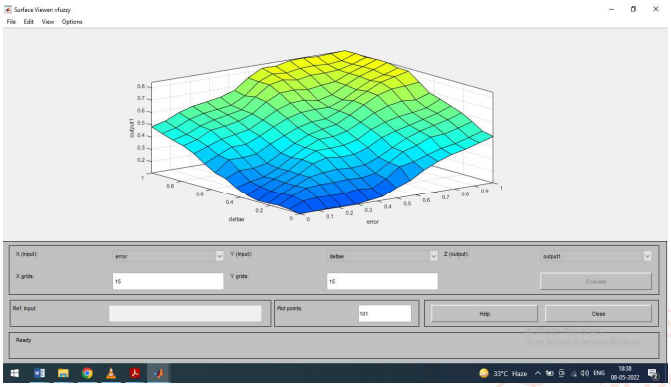

Figure4 Surface view of fuzzy control system

Inverter control

In this proposed wind energy system the output ac voltage is controlled through amplitude and frequency. Power from PMSG based wind turbine is fed to ac-dc-ac converters to maintain the output voltage at desired amplitude and frequency. The reactive power and an active power exchange with the grid are function of phase and amplitude of terminal voltage at AC terminals of a GSC. The objective of controlling a GSC is to keep constant DC link voltage under change in generated active power while keeping sinusoidal currents of PMSG as shown in figure 4.[5]

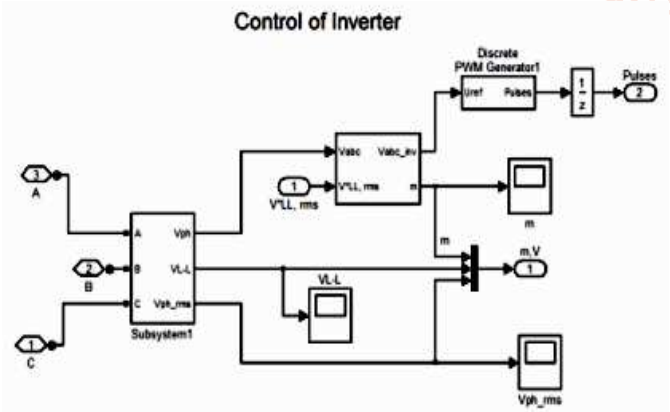

Figure 5 Subsystem of control system of inverter

Conversion of AC source through Dc sources is achieved by a device known as inverter. Starting from a small switching device to large electricity applications like bulk power transmission inverters are extensively used. Pulse width modulation is a powerful technique for controlling analog circuits with a processors digital output. [3] [4]

The proposed model uses the technique where the variable load is connected to the output of inverter so whenever there is variation in voltage it can be normalized by control methodology process. The voltage at the output of inverter is fed back to the controller where it is compared with the reference bus voltage. The error is then controlled and normalized through PI controller. The proper tuning of proportional and integrator gain is done by initial assumptions.

The PI controller output is in unit tolerance band and to make it alternate proportional to the bus voltage PLL block is used. The pulses generated from PWM generator block is of variable width.

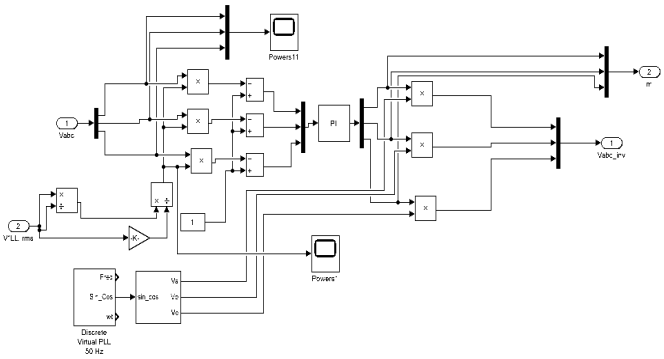

Figure 6 Simulink model of controller

This control system of inverter consists of three main subsystems. The first subsystem is voltage measurement block. This block measured three phase voltage of load side as it varies as voltage magnitude varies. This voltage is then converted to phase voltage, line voltage and rms value of phase voltage. The next subsystem is controller. The VLL gives the reference line voltage which has to be maintained across the grid. This VLL is then multiplied with the rms value of phase voltage and the obtained value is compared with the unit value. The produced signal is given to the PI controller. The values of gain in PI controller is set to normalize the voltage value, the signal generated from PI controller is a DC signal. So in order to make a perfect sinusoidal signal a PLL block is added to match the bus sinusoidal voltage and frequency. The output of this controller then passes through the PWM generator. This PWM generator compares the sinusoidal signal with the triangular wave and then generates the firing pulses by PWM modulation technique.[5]

PROPOSED MODEL

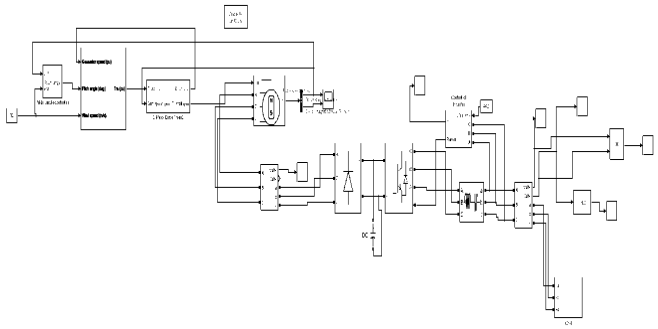

Figure 8 Proposed model

The proposed model describes a wind turbine connected with the two mass drive train and synchronous generator using the power electronics converter like diode based machine side converter and igbt based grid side converter with PWM based control system to get suitable gate pulse and then connected with the grid system. A fuzzy based pitch control system has been designed to get much better power as well as smooth current and voltage in different weather conditions. All the simulation was done on Matlab Simulink platform and the results are analyzed.

Various measurement system has been placed at various stages to measure all the parameters for the research and analysis at various stages of the system.

RESULTS

Figure 8 Three phase voltage at output

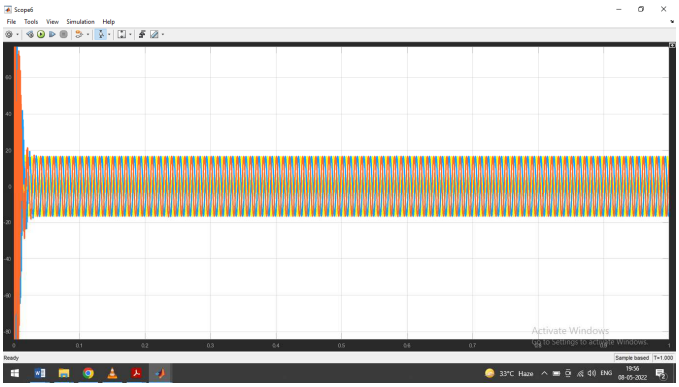

Figure 9 Power with PID control

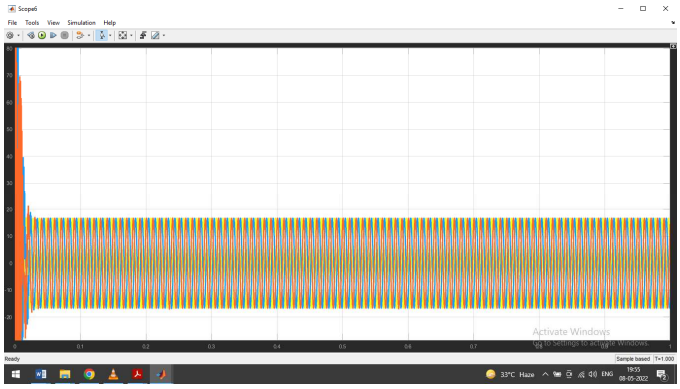

Figure 10 Power with Fuzzy control

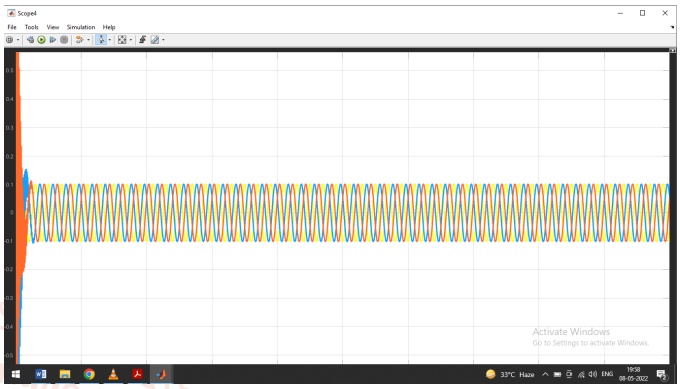

Figure 11 Current with PID control

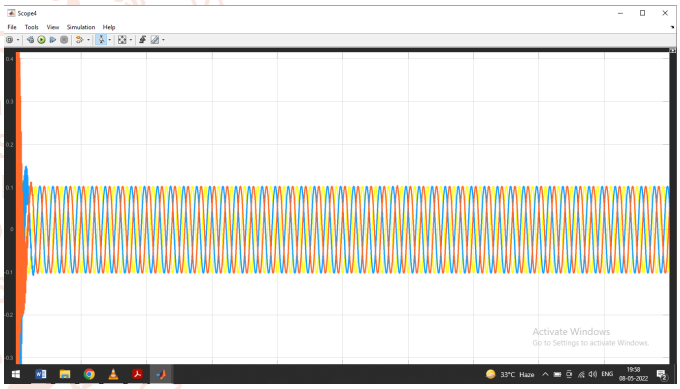

Figure 12 Current with Fuzzy control

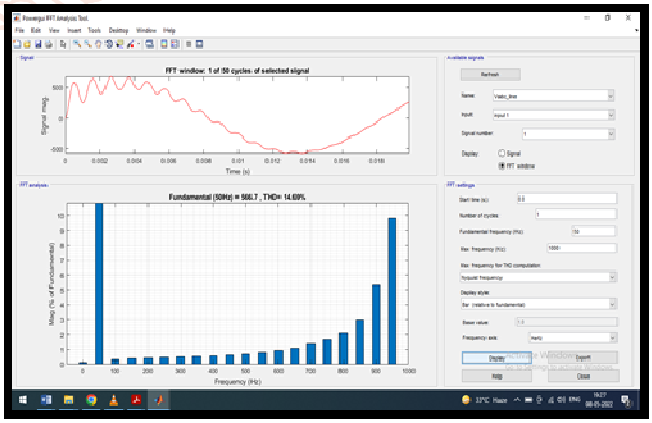

Figure 12 FFT analysis with PID control

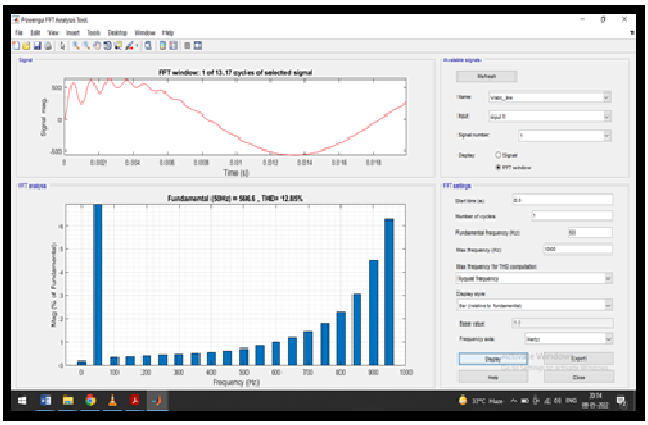

Figure 12 FFT analysis with fuzzy control

S.NO	Wind turbine parameters	
	Name of block	Specification
1	Density of air	1.225 Kg/m3
2	Area swept by blades	1.06 m2
3	Base wind speed	12 m/s

CONCLUSION

As we can see in the results the conventional PID control for pitch control has been placed in the pitch control system and outputs taken as well as the fuzzy control system has been attached with the model pitch control system and the results were analyzed and power output with fuzzy control system is having a bit higher amplitude as well as same in the current waveform. Fast Fourier transform analysis has been done in both the cases and we can see that in conventional case total harmonic distortion is near about 14% and this amount has been reduced by about 2% with the fuzzy control system. Further analysis can be done with a better design of fuzzy control with some new enhanced rule table so that to get a much better output.

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